From: Jen Mott <jmott@anchorqea.com>
Sent: Monday, August 29, 2016 4:05 PM
To: HarborComments
Cc: Koch, Kristine; Sheldrake, Sean; Jen Mott; Bob Wyatt; Patty Dost; Carl Stivers; Amanda Shellenberger; John Verduin; brandy.humphreys@grandronde.org; audiehuber@ctuir.com; callie@ridolfi.com; Courtney Johnson (courtney@crag.org); Elmer Ward (elmer.ward@ctwsbnr.org);(b) (6) Gail French Fricano (GFricano@indecon.com); Holly Partridge (Holly.Partridge@grandronde.org); Jennifer Kassakian (jkassakian@indecon.com); Julie Weis; Kim D'Aquila (kim.daquila@grandronde.org); Laura Klasner Shira (shil@yakamafish-nsn.gov); Madalinski, Kelly; MCCLINCY Matt; Michael.karnosh@grandronde.org; Rachel DelVecchio (rdelvecchio@indecon.com); Rita Cabral; Robert.Neely@noaa.gov; rose@yakamafish-nsn.gov; Sarah Greenfield (greenfield.sarah@deq.state.or.us); tomd@ctsi.nsn.us
Subject: Partial LWG Comments On Portland Harbor Proposed Plan
Attachments: Cost Evaluation Memorandum_08-29-2016.pdf

EPA Region 10,

The attached document provides an early set of comments from the Lower Willamette Group that focus specifically on the cost analysis presented in EPA's Proposed Plan for the Portland Harbor Superfund site. The LWG will be providing a full set comments on the Proposed Plan prior to the deadline established for the public comment period.

Thank you,
Jen Mott J
Anchor QEA, LLC
jmott@anchorqea.com
421 SW Sixth Avenue, Suite 750
Portland, OR 97204
503-972-5014

EPA COST EVALUATION

This memorandum presents an analysis of the U.S. Environmental Protection Agency's (EPA's) cost estimate presented in the Feasibility Study for Alternative I, which was selected as EPA's Preferred Alternative in the Proposed Plan. The Lower Willamette Group (LWG) reviewed in detail EPA's cost estimate for its preferred Alternative I and prepared a cost estimate organized in the same categories as EPA to provide an "apples to apples" comparison of differences. The LWG prepared its cost estimate following EPA guidance (EPA 2000). Table 1 describes the approaches that EPA and the LWG used to develop costs for each element. The LWG used EPA quantities and unit costs where appropriate and developed new values where EPA values were felt to be significantly in error—Table 1 summarizes how quantities and unit costs were developed for the LWG cost estimate as compared to EPA values. Table 2 compares the estimated costs for each element. Table 3 compares the present value analyses for EPA and the LWG's cost estimates.

The LWG has concerns with a number of elements of EPA's cost estimate, including the following:

- Contingency—EPA uses a low end contingency percentage. EPA acknowledges it is on the low end of EPA guidance and justifies the low percentage "due to the high overall costs for major work activities and a detailed level of conceptual design performed as part of the technology assignment modeling." The LWG feels that the technology assignment modeling is very conceptual in nature and that the unknowns, unforeseen circumstances, and unanticipated conditions associated with applying these conceptual technologies are significant and justify a much higher contingency.
- Water quality control structures—EPA is requiring the installation of sheetpiling around principal threat waste dredge areas out into the deeper water of the channel, but its cost estimate is for less reinforced structures located in shallower water. The LWG feels that the sheetpile structures as described by EPA are not constructable and may not be legal to create an obstruction that would be a hazard to navigation. Therefore, the LWG presents costs for structures that are located in shallower waters than identified by EPA.
- Fixed arm vs. cable bucket dredging—EPA, in the Proposed Plan, states that fixed arm buckets will be required except where the water is too deep. However, EPA prepared its cost estimate assuming 94% of the dredging would be done with the faster and less expensive cable bucket when, in fact, the fixed arm equipment can only reach 65% of the dredge volume.
- Sediment handling and disposal—EPA is assuming that all of the Subtitle D material will be barged to Bingen, Washington, and all of the Subtitle C material will be barged to Boardman, Oregon. Materials would be offloaded in these locations and then hauled by truck to the respective landfill. The LWG has concerns about the ability of these offloading locations to handle the estimated quantities of material in a safe and cost-effective manner, as well as the infrastructure between the proposed offloading facilities and the respective landfills. Millions of cubic yards of material will need to be shipped through the proposed offloading facilities and onto the roads.
- Dredge volumes—EPA does not assume any additional dredge materials below unbounded cores (cores with bottom samples still elevated), which account for 20% of all

the cores. The LWG believes it is prudent to assume some additional amount of contamination beneath unbounded cores.

- Cap overplacement—EPA only includes neat line volumes for caps and does not include overplacement allowance to account for construction tolerances.
- Production rates—EPA assumes aggressive dredging and capping production rates, which produce unrealistic lower unit costs and shorter construction durations. EPA has assumed that the dredging operation would be working 81% of the time. Past experience on environmental dredging projects indicates this percentage is inappropriately high. In addition, the Willamette River is an active waterway, which would further impact operation up time to allow commercial ship passage. The video at this link provides a visual example of how active vessel traffic in navigation areas will impact dredge production rates: http://dofnw.com/animation/.
- Project durations—EPA's shortened durations have an unreasonable "trickle down" cost reduction effect on other cost elements, such as the transload facility and water treatment.
- Mobilization and demobilization—EPA uses a very low percentage of direct capital costs to estimate mobilization/demobilization costs instead of estimating likely costs based on project duration and scope.
- Indirect costs—EPA uses very low end percentages for remedial design, project management, and construction management. The FS acknowledged that these percentages were "modified to lower than the recommended range presented in the guidance" due to the high overall construction costs.
- DSL fees—EPA stated that DSL fees for permanent caps are included in "project management", which is 2% of the direct construction costs (note, that the LWG's estimate for DSL fees would account for over 60% of EPA's project management cost element). The LWG feels that the DSL fees need to have a separate line item.
- Discount rate—As LWG has previously commented, EPA's 7% discount rate is unreasonably high. EPA guidance recommends financial assurance at the OMB Circular A-94 rate, which makes it a far more accurate estimate of actual project cost to responsible parties. It should be noted that responsible parties at the Portland Harbor CERCLA site, including the federal government, are public entities for whom the 7% rate is practically (and potentially legally) unachievable. The LWG used a 2.3% discount rate that is entirely consistent with the OMB Circular A-94 as referenced in EPA guidance.

References

EPA (U.S. Environmental Protection Agency). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540-R-00-002. OWSER 9355.0-75. July 2000.

Attachments

Table 1 Comparison of EPA's and LWG's Approaches on Cost Estimate for Alternative I DMM Scenario 2

Table 2 Comparison of EPA and LWG Cost Approach

Table 3 Present Value Analysis Comparison

ATTACHMENTS

Table 1. Comparison of EPA's and LWG's Approaches on Cost Estimate for Alternative I DMM Scenario 2.

Cost Item	EPA Approach	LWG Approach
Direct Construction Capital Costs		
Mobilization/Demobilization	**Description:** Project setup; mobilization and demobilization of all equipment to and from the site at the project beginning and end and before and after each season. **Unit Cost:** EPA assumed 1.6% of total capital costs based on the Lower Duwamish FS cost estimate, which is $9,045,000. (Note: The Lower Duwamish FS cost estimate assumed $800,000 initial mobilization/demobilization and then $120,000 each season, which was 1.6% of the total capital cost.) **Quantity:** NA	**Description:** The LWG developed mobilization/demobilization costs given the anticipated equipment needs for the Alternative I remedy activities. The LWG assumed costs to set up the contractor's trailer site, mobilize/demobilize dredge and cap plants, tugs and material scows as well as costs to develop contractor plans. **Unit Cost:** The first year cost was assumed to be $4.5 million and each subsequent year was assumed to be $2.9 million. As a comparison, the estimated mobilization/demobilization is 4.6% using this approach. **Quantity:** Number of seasons.
Debris Removal and Disposal	**Description:** Removal and disposal of debris for all areas prior to remedial activities. **Unit Cost:** EPA used the LWG's 2012 unit rates adjusted for inflation for debris removal and disposal: $13,107/acre **Quantity:** EPA assumed the entire active remediation area required debris removal.	**Description:** The LWG used the 2012 unit rates adjusted for inflation. (Typical note: the CWCCIS Amendment 8 [March 2016] factor has a slightly lower inflation correction than CWCCIS Amendment 7 [Fall 2015] factor that EPA used.) **Unit Cost:** Debris removal and disposal: $12,942/acre. **Quantity:** The LWG used EPA quantities.
Obstruction Removal and Relocation	**Description:** Obstruction removal, relocation, and disposal. Specifically, pile removal and disposal, pile replacement, and temporary dock relocation. **Unit Cost:** EPA used the LWG's 2012 unit rates adjusted for inflation for obstruction removal and disposal as necessary: • Pile removal and disposal: $716/pile • Pile replacement: $7,479/pile • Temporary dock relocation: $100,498/dock **Quantity:** EPA counted piling from overlay of Google Earth.	**Description:** The LWG used the 2012 unit rates adjusted for inflation **Unit Cost:** • Pile removal and disposal: $707/pile • Pile replacement: $7,385/pile • Temporary dock relocation: $99,233/dock **Quantity:** The LWG used EPA quantities.
Erosion/Residual Control Measures (Dredge Water Quality Controls)	**Description:** Installation, maintenance, and removal of silt curtains and sheetpile walls. **Unit Cost:** EPA used the LWG's 2012 unit rates adjusted for inflation for silt curtains and sheetpiling. • $2,749.88/lf for sheetpile walls • $96.92/lf for silt curtains **Quantity:** EPA assumed length of silt curtains by encircling dredge and/or cap areas shown on the technology assignment figures. Sheetpile lengths are estimated by encircling NAPL PTW dredge or cap areas.	**Description:** The LWG updated the sheetpile costs presented in the 2012 FS to reflect EPA's current requirement to surround NAPL PTW. This requirement will have the sheetpile wall out in deeper water. The sheetpile wall, as located by EPA, is likely not constructable in water that deep. The LWG estimated the cost for a sheetpile wall located in approximately 40 feet of water, which is significantly more expensive than the costs developed by EPA. The structure out further in water will also likely be a hindrance to navigation. The LWG did not include costs to remove the structure each season—the structures are in place until the work is completed. **Unit Cost:** Contractor estimated costs for sheetpile walls are $17,600/lf. This is for a complex structure that goes from shore out into deeper water (~40 feet of water). The LWG's 2012 unit rates assumed a simpler sheetpile wall in shallower water. Silt curtain unit costs used by the EPA, adjusted for inflation, appear reasonable at $95.70/lf. **Quantity:** The LWG used EPA quantities.
Dredging of Contaminated Sediments (Open Water)	**Description:** In water deeper than 40 feet (roughly mudline elevation of -30 feet NAVD88), EPA assumed use of a 10 cy cable bucket, 24 hours per day. Two of these dredge plants would operate at a time, removing 4,764 cy per 24-hour day. EPA's cost assumed 94% of the dredging would be completed with this type of dredge, even though it says the open water approach would only be used in water deeper than 40 feet. **Unit Cost:** EPA assumed daily costs for the two dredge plants working 24 hours/day of $117,000 for a unit cost of $24.53/cy. Costs are only for dredging. EPA's production rates and hence the unit costs do not appear to reflect the FS BMPs EPA implies will be required. **Quantity:** Dredge volumes for costing purposed were estimated by EPA assuming 1.75 times the neat line dredge volume. (The volume shown in the EPA FS and PP are based on a neat line dredge volume of 2.0.) EPA's FS and PP have conflicting descriptions on how depths were determined. The FS stated that depths were controlled by the PRG; the PP stated that the depths were controlled by RALs. Review of the core data compared to the cost estimate indicates that EPA used the RALs to determine neat line dredge depths. It appears that no additional depth was added to unbounded cores that had bottom samples still exceeding RALs (even though about 20% of the cores still exceeded RALs at the bottom).	**Description:** EPA's cost estimate accounts for a mixed use of cable bucket and fixed arm bucket dredging. LWG used the same approach; however, the LWG followed EPA's stated requirements of using the fixed arm bucket in shallow water and cable bucket only in deeper water. The LWG assumed 65% of the dredge volume would be removed with the fixed arm bucket (in water shallower than 40 feet) and 35% of the dredge volume would be removed with cable bucket, based on actual mudline elevations within the EPA-defined dredge areas. The LWG assumed the dredging would only occur 12 hours per day. Because of the large volume of confined material, the LWG assumed two fixed arm dredge plants and one cable bucket plant working continuously. **Unit Cost:** The LWG developed unit costs using EPA's estimated daily shift costs, but using more realistic shift production rates for the two different pieces of equipment. Production rates reflect BMPs EPA implies use of in the FS including reduction of cycle times, reducing or stopping dredging during periods of peak current, rinsing the bucket between loads, and stopping the bucket at the waterline to allow excess water to drain. In addition, EPA aggressively assumed that the dredging operation would be operational 81% of the time. Experience on environmental dredging projects indicates that the operational effectiveness is closer to 50 to 60%. In addition, the Willamette River is an active waterway, which would further impact operation efficiency. Vessel traffic impacts will occur, on average, 5 to 7 times a day within the channel as a consequence of both marine traffic arrivals and departures as well as intra-harbor barge movements. Based on these and other factors, such as offloading capacity, the LWG used the following unit rates: • Cable bucket: 700 cy/plant/shift at $29,215/plant/shift or $41.74/cy • Fixed arm bucket: 450 cy/plant/shift at $22,174/plant/shift or $49.28/cy • Riverbank excavation: 450 cy/plant/shift at $14,634/plant/shift or $32.52/cy **Quantity:** The LWG developed dredge quantities using EPA's neat line volume as a basis. This volume was increased to account for potential additional volume in areas where depths were determined by unbounded cores (roughly 20% of the total cores) by adding 2 feet of additional contamination to account for uncertainty. An additional 1 foot of allowable overdredge was added to the entire dredge area. This total volume was then multiplied by 1.5 to account for side slopes and other factors (based on engineering design experience). Approximate dredge volumes were differentiated between shallower than elevation -30 feet NAVD88 and deeper and assigned to the appropriate dredge technology (63% fixed arm; 37% cable). The LWG used EPA riverbank quantities as it was too difficult to understand EPA assumptions enough to refine the quantities.
Dredging of Contaminated Sediments (Confined)	**Description:** In water shallower than 40 feet (roughly mudline elevation of -30 feet NAVD88), EPA assumed use of a 2- to 4-cy fixed arm bucket on an excavator, 24 hours per day. One of these dredge plants would operate at time, removing 1,426 cy per 24-hour day. EPA's cost assumed only 6% of the dredging would be completed with this type of dredge. **Unit Cost:** EPA assumed daily costs for the 1 dredge plant working 24 hours/day of $44,000 for a unit cost of $31.10/cy. Costs are only for dredging. EPA's production rates and hence the unit costs do not appear to reflect the FS BMPs EPA implies will be required. **Quantity:** See above for open water dredge volume quantities.	
Excavation of Riverbanks	**Description:** Riverbank work would be conducted using a 6.5-cy bucket on an excavator and a conveyor to transfer material to a haul barge. One of these dredge plants will be operating at a time only during the day, removing 2,821 cy per 12-hour day. **Unit Cost:** EPA assumed daily costs for the 1 dredge plant working 12 hours/day of $15,000 for a unit cost of $5.19/cy. EPA's production rates and hence the unit costs do not appear to reflect the FS BMPs EPA implies will be required. **Quantity:** Excavation volumes are estimated by multiplying the length of riverbank to be excavated by the cross-sectional area of the excavation surface. EPA assumed a 3-foot cut perpendicular to the slope. Volume multiplied by 1.12 to account for bulking.	

Cost Item	EPA Approach	LWG Approach
Dewatering and Water Treatment for Dredging Operations	**Description:** EPA assumed water treatment required only during days of dredging. Water treatment appears to consist of a frac tank with carbon treatment on a flat deck barge. It appears the treated water would be discharged back to the river. **Unit Cost:** EPA assumed $36,600 per season to mobilize/ demobilize the treatment plant and then $21,654/day to operate. **Quantity:** EPA assumed water treatment required only during days of dredging. The number of dredge days was estimated assuming 5,000 cy/day removal.	**Description:** The LWG assumed the same water treatment process as EPA with discharge back to the river. This cost does not include discharge to a POTW if discharge back to the river is not allowed. The LWG believes the plant will need to be up and operational during the full dredging duration as well as some lag time during demobilization of the transload facility as it will need to treat any contact water generated from storms. **Unit Cost**: EPA's costing approach was used with the concerns noted above: $36,600 per season to mobilize/demobilize and $21,654/day to operate. **Quantity:** The LWG used the dredging duration plus 10% to account for any contact water during lag times.
Subtitle C/TSCA Disposal (Handling, Transportation, Treatment of Select PTW Materials, and Disposal)	**Description:** EPA has made the assumption that transloading of materials will be outside of Portland Harbor. EPA's process assumed in-barge mixing of amendments (quicklime and DE), barge transport to a transload facility, material handling to a truck, transport and disposal at Chem Waste (Subtitle C) landfill. EPA assumed the material would be hauled by barge from the dredge site to the Port of Morrow, near Boardman, Oregon, offloaded into trucks, and hauled to Chem Waste. **Unit Cost:** EPA assumed two plants working 24 hours/day with an excavator on a barge stabilizing the sediment with DE and quicklime at $24.5/cy plus amendments within the haul barges; $40,980 per 3,000 cy barge load to haul sediments to Boardman ($13.66/cy) assuming 24 hours trip up and 18 hours back; two plants working 24 hours/day offloading barges with a 10-cy bucket at 6,864 cy/day for $9.70/cy; 1, 4-cy excavator loading trucks at $2.68/cy; 15, 20-cy trucks hauling 45 miles to landfill at $16.70/cy; tipping fee quote from Chem Waste at $86.10/ton; and thermal desorption treatment quote from Chem Waste at $578.64/ton for high end and $322.60/ton for low end. The total estimated transportation, treatment, and disposal cost following the method described above is $311/cy. **Quantity:** All PTW NRC/NAPL from SDU 6W would require quicklime treatment prior to disposal. One-third of NRC/NAPL PTW from SDU 7W would require quicklime treatment prior to disposal; one-third low temperature thermal desorption prior to disposal; and one-third no treatment prior to disposal. Dredge quantities based on dredge volumes described above.	**Description:** The LWG assumed a central Portland Harbor transload facility with rail transport from the facility. The LWG does not believe Boardman is capable of handling the quantities estimated based on site experience transloading Gasco Early Action Area sediments through the site. The LWG's process includes mixing in quicklime and DE on the barge, hauling the sediments to the transload facility, offloading the barge, loading into rail cars, transporting and disposing at Chem Waste. The LWG assumed the same treatment approaches for the Subtitle C material. The LWG used EPA's approach of stabilizing the sediments on the barge although it is likely more efficient to stabilize on land after transloading. **Unit Cost:** The LWG used the same treatment costs as EPA. The total estimated transportation, treatment, and disposal cost following the method described above is about $370/cy. **Quantity:** The LWG assumed EPA's Subtitle C volumes and percentages regarding treatment of Subtitle C material.
Subtitle D Disposal (Handling, Transportation, and Disposal)	**Description:** EPA has made the assumption that transloading of materials will be outside of Portland Harbor. EPA process assumed including in-barge mixing of amendments (DE), barge transport to a transload facility, material handling to a truck, and transport and disposal at Roosevelt Regional (Subtitle D) landfill in Washington. EPA assumed the material would be hauled by barge from the dredge site to Bingen, Washington, offloaded, and hauled by truck to Roosevelt. **Unit Cost:** EPA assumed two plants working 24 hours/day with an excavator on a barge stabilizing the sediment with DE at $24.5/cy plus amendments within the haul barges; $40,980 per 3,000 cy barge load to haul sediments to Bingen ($13.66/cy), assuming a 24-hour trip up and 18-hour trip back; and transloading of sediments, truck transport to landfill, and tipping fee quote from Roosevelt Landfill of $74.54/ton. The total estimated transportation, stabilization, and disposal cost following the method described above is $139/cy. **Quantity:** All remaining materials are disposed at Subtitle D landfill in Alternative I.	**Description:** The LWG assumed central Portland Harbor transload facility with rail transport from the facility. The LWG does not believe Bingen and the surrounding infrastructure is capable of handling the quantities estimated. Process includes mixing in DE, hauling the sediments to the transload facility, offloading the barge, loading into rail cars, transporting, and disposing at Roosevelt. The LWG used EPA's approach of stabilizing the sediments on the barge although it is likely more efficient to stabilize on land after transloading. **Unit Cost:** The total estimated transportation, stabilization, and disposal cost following the method described above is about $165/cy. **Quantity**: As stated above for dredge volumes, the volumes were increased to account for unbounded core uncertainty.
Mitigation	**Description:** EPA assumed all in-water areas as well as riverbank areas with armoring above -13 feet NAVD88 will require mitigation no matter the current substrate or habitat condition. EPA is also requiring habitat mix on all armor material in effect requiring mitigation twice for the same impact. **Unit Cost:** EPA appears to use the average costs of mitigation site normalized per acre ($1 million per acre). **Quantity:** Sum of in-water and riverbank areas with armoring above -13 feet NAVD88.	**Description:** The Draft CWA 404(b)(1) in the EPA FS states that mitigation projects can occur within the 4th level HUC (i.e., Lower Willamette SubBasin), which includes areas both inside and outside of Portland Harbor and is the same watershed area that the LWG identified in its FS. Based on this, the LWG took an average cost from both on-site and off-site mitigation projects to derive an opinion of mitigation costs. **Unit Cost:** The LWG's updated range of restoration costs for projects occurring on site within Portland Harbor is $1.95 to $3.65 million per acre and a range for off-site restoration costs is $505,500 to $1,335,500 per acre (with acquisition included). The average low end and average high end of the cost ranges for on-site and off-site areas is $1,227,750 to $2,492,750 per acre, or rounded to $1.2 to $2.5 million per acre. An average of $1.85 million per acre was used, assuming half the mitigation will occur off-site and half on-site. **Quantity**: The LWG believes EPA's approach to estimating mitigation acreage is overly conservative because it is not considering the existing condition of the areas that will be armored and the habitat function that is provided and is just assuming each area covered with armoring will automatically need to be mitigated at a 1:1 ratio. Given this, the LWG still used EPA's estimated 34 acres of required mitigation for this exercise because enough information to calculate mitigation requirements does not exist at this time.
DSL Costs	**Description:** EPA, in a follow up email from Kristine Koch on July 20, 2016, said that "fees not otherwise covered by a direct line item are covered by a percentage of the capital and periodic costs in the professional/technical oversight named 'project management.'" So it states the costs are covered in the 2% Project Management line item. **Unit Cost:** EPA does not present a line item for DSL costs. **Quantity:** EPA does not present a line item for DSL costs.	**Description:** For areas where a permanent cap is placed on DSL land, costs are included to purchase or lease the land. Unit costs for purchasing or leasing land were estimated from Oregon Administrative Rules 141-082-0100. **Unit Cost:** $142,879 per acre from EPA's estimate was assumed. (EPA provided an estimate for DSL costs, but did not include them in their cost estimate.) **Quantity:** The LWG estimated the area from a GIS layer provided by DSL and shown in Figure 1.2-2 of the EPA FS—the LWG assumed all caps on DSL property will require this fee.

Cost Item	EPA Approach	LWG Approach
Sand Placement for Technology Assignments	**Description:** EPA assumed sand material would be placed using three different approaches. In addition to the defined cap sections, these quantities and costs also include daily residual cover. EPA assumed 77% of capping done with open water approach, 14% with the riverbank approach, and 9% with the confined approach. **Unit Cost:** Open water placement assumed 1 plant with a 10-cy clamshell bucket working 24 hours/day placing 4,574 cy/day with a survey crew for a total of $56,800/day ($12.42/cy); Confined water and riverbank placement assumed 1 plant with a 4-cy fixed arm bucket working 12 hours/day placing 1,166 cy/day at $23,800/day ($20.39/cy). Material costs were based on the LWG 2012 FS, increased for inflation. EPA developed an overall unit cost of $34/cy using the above information for total purchase and placement. **Quantity:** EPA used the neat line cap thickness times the area of coverage (did not include any overplacement allowance).	**Description:** The LWG assumed two cable bucket plants and one fixed arm plant will be placing cap materials continuously. In addition to the defined cap sections (thickness of each layer), these quantities and costs also include daily residual cover, as EPA notes is required on Page 29 of the Proposed Plan. **Unit Cost:** The LWG developed unit costs using EPA's estimated daily shift costs, but using more realistic shift production rates (based on past experience) for the two different pieces of equipment: • Cable bucket: 1,000 cy/plant/shift at $28,406/plant/shift or $28.41/cy • Fixed arm bucket: 600 cy/plant/shift at $23,780/plant/shift or $39.63/cy • Riverbank excavation: 600 cy/plant/shift at $23,775/plant/shift or $39.63/cy Material costs assumed by the LWG are consistent with EPA's: • Sand $19.50/ton • Beach Mix $56.96/ton • Armor (ODOT 200) $56.96 **Quantity:** The LWG developed cap quantities using EPA's cap quantities, except the LWG included overplacement allowances of 0.5 foot for sand (including daily cover) and 1 foot for beach mix and armor materials given the target thicknesses, material gradations, and equipment tolerances (overplacement allowances do not appear to be included by EPA).
Beach Mix Placement for Technology Assignments	**Description:** EPA assumed beach mix material would be placed using the same methods as for sand placement. EPA assumed 58% of capping done with open water approach, 32% with the riverbank approach, and 10% with the confined approach. **Unit Cost:** EPA assumed the same unit pricing for placement as it used for Sand Placement. Material costs based on the LWG 2012 FS, increased for inflation. EPA developed an overall unit cost of $73.43/cy using the above information for total purchase and placement. **Quantity:** EPA used the neat line cap thickness times the area of coverage (did not include any overplacement allowance).	
Armor Placement for Technology Assignments	**Description:** EPA assumed armor material would be placed using the same methods as for sand placement. EPA assumed 73% of capping done with open water approach, 2% with the riverbank approach, and 25% with the confined approach. **Unit Cost:** EPA assumed the same unit pricing for placement as it used for Sand Placement. Material costs based on the LWG 2012 FS, increased for inflation. EPA developed an overall unit cost of $72.27/cy using the above information for total purchase and placement. **Quantity:** EPA used the neat line cap thickness times the area of coverage (did not include any overplacement allowance).	
Reactive/GAC Placement for Technology Assignments	**Description:** EPA assumed mixture of AquaGate+PAC 10% with sand to obtain an activated carbon content of 5% (50% sand mixed with 50% AquaGate+PAC 10%). EPA assumed 86% of the mixture would be placed with the open water placement method and 14% with confined placement methods. In addition, EPA assumed AquaBlok would be used below structures to create an impermeable layer. EPA assumed the AquaBlok material would be placed underpier using the confined placement approach. **Unit Cost:** EPA assumed the same unit pricing for mixture placement as it used for sand placement. Sand costs were based on the LWG 2012 FS, increased for inflation. Material prices for AquaGate+PAC 10% and AquaBlok were obtained directly from AquaBlok. EPA assumed $4.76/cy for mixing the materials together but did not provide details on the approach. EPA developed an overall lump sum cost of $44,759,377 using the above information for total purchase and placement. **Quantity:** Used the neat line cap thickness times the area of coverage (did not include any overplacement allowance).	**Description:** The LWG assumed the same mixture concertation and material as EPA. This will need to be confirmed as part of remedial design. **Unit Cost:** The LWG placement costs are as discussed above for cap materials. Material costs assumed by the LWG are consistent with EPA's: • Sand $19.75/ton • AquaGate+PAC 10% $479.12/ton based on quote from AquaBlok • Mixing of sand and AquaGate $4.76/cy • AquaBlok $212.94/ton, based on quote from AquaBlok **Quantity:** The LWG developed cap quantities using EPA's cap quantities, except the LWG included overplacement allowances of 0.5 feet for sand and 1.0 feet for beach mix and armor materials given the target thicknesses, material gradations, and equipment tolerances (overplacement allowances do not appear to be included by EPA).
Geofabric for Riverbanks	**Description:** EPA assumed placement of a geotextile underneath the riverbank cap. **Unit Cost:** EPA used vendor quotes for purchase and installation. **Quantity:** EPA assumed geotextile under the entire riverbank work.	**Description:** The LWG assumed placement of a geotextile underneath the riverbank cap. **Unit Cost:** The LWG used EPA's vendor quotes for purchase and installation at $14,311/sf **Quantity:** The LWG used EPA's estimated geotextile area. There was not enough information provided to verify EPA's assumptions.
Organoclay Mat Placement for Technology Assignments	**Description:** EPA assumed mat placed in areas where NAPL or PTW cannot be reliably contained that is left in place (significantly augmented reactive cap). EPA assumed one crew working 12 hours/day using a tug, barge mounted crane, and divers for the confined areas. **Unit Cost:** EPA assumed 12,000 sf can be placed per day at a cost of $40,000 ($3.35/sf). Mat material costs were based on the LWG 2012 FS, increased for inflation. EPA developed an overall unit cost of $6.73/sf using the above information for total purchase and placement. **Quantity:** EPA assumed the mats will be placed in location where NAPL or PTW cannot be removed and is left in place.	**Description:** EPA's assumptions and costing approach appears reasonable. **Unit Cost:** used EPA's vendor quotes for purchase and installation at $6.65/sf. **Quantity:** The LWG used EPA's estimated organoclay mat area. There was not enough information provided to verify EPA's assumptions.
Transload Facility Development	**Description:** EPA assumed the construction of one 20-acre transloading facility located in the harbor to operate for 7 years. This conflicts with the way EPA costed the disposal scenario where it had two separate transload facilities up the Columbia River (one for Subtitle C and one for Subtitle D transloading). EPA used the LWG 2012 transload facility costs, increased for inflation, but excluding costs for new rail line and switches nor mobilizing train gondolas each year. **Unit Cost:** EPA developed a cost of $10.5 million to construct and operate a Portland Harbor transload facility for 7 years. **Quantity:** NA	**Description:** The LWG assumed the construction of one 20-acre transloading facility located in Portland Harbor to operate for the duration of dredging. Sediments would be barged to the transload facility, offloaded at the facility and shipped by rail to either ChemWaste or Roosevelt landfills. **Unit Cost:** The LWG included costs for site permitting, facility development, yearly lease, yearly gondola mobilization, and yearly inspection and monitoring. **Quantity:** NA

Cost Item	EPA Approach	LWG Approach
In-Direct Construction Capital Costs		
Contingency	**Description:** EPA stated that "due to the high overall costs for major work activities and a detailed level of conceptual design performed as part of the technology assignment modeling, the scope contingency percentages were modified to the low end of the recommended range presented in the guidance, to better reflect the detailed evaluation and concepts developed for these items." **Unit Cost:** EPA used the following contingencies: • 15% for implementing institutional controls • 10% for maintaining institutional controls • 10% for 5-year site review periodic costs • 20% for MNR capital costs, technology assignments measures capital construction costs, site-wide monitoring and MNR periodic costs, and long-term O&M periodic costs	The LWG assumed a contingency of 40% of the total direct construction costs. EPA (2000) states that contingencies for alternatives screening and/or detailed analysis of alternatives can be as high as 50%. EPA (2000) notes two types of contingency that need to be accounted for: scope and bid. EPA (2000) states that scope contingency "represents project risks associated with an incomplete design." "At the early stages of remedial design (e.g., FS which represents 0% to 10% design completion), concepts are not typically developed enough to identify all project components or quantities." "Scope contingency typically ranges from 10 to 25 percent. Higher values may be justified for alternatives with greater levels of cost growth potential." Exhibit 5-6 of EPA (2000) lists the remedial technology of soil excavation typically having scope contingencies of 15 to 55%. Given the limited site data, large extent of the site, and uncertainty with the Proposed Plan language regarding design, the LWG believes 25 to 30% for scope contingency is appropriate. EPA (2000) states that bid contingency accounts for changes that occur after the construction contract is awarded and represents a reserve for quantity overruns, modifications, change order, and/or claims during construction. Factors include "adverse weather, material or supply shortages, or new regulations." Per EPA (2000), "bid contingency typically ranges from 10 to 20 percent." Given the historically complex nature of remedial work in waterbodies, especially active rivers, the LWG believes 15% is appropriate for bid contingency. Finally, EPA (2000) states that "total contingency value (bid+scope) that is applied to annual O&M costs is typically equal to or greater than the contingency applied to capital costs."
Remedial Design	**Description:** EPA stated that "due to the high overall costs for major work activities, the professional/technical percentages were modified to lower than the recommended range presented in the guidance, to better reflect realistic costs for professional/technical services costs for these items." **Unit Cost:** EPA used the following percentages for remedial design: • 2% of technology capital costs for remedial design (this worked out to only $14 million for Alternative I) • 2% for institutional controls costs • 8% of capital costs for MNR monitoring	Remedial design costs include pre-remedial design sampling and analysis to define the extent of required remediation, modeling and design calculations, construction document preparation, contractor procurement, and agency negotiations. Elements to be designed include the lateral and vertical extent of dredging, lateral extent of capping, cap thickness, composition, armoring requirements, transload facility(s), material handling, water treatment, debris identification and handling, infrastructure coordination, construction quality control programs, environmental monitoring programs, and long-term monitoring programs to name a few. As a point of reference, the LWG has spent over $100 million in the RI/FS process alone, due to the site's size and the regulatory environment. Remedial design will be at least that amount, given the same issues (project size and regulatory environment). As another line of evidence, EPA (2000; Exhibit 5-8) recommends at least 6% of capital costs be anticipated for remedial design. The LWG assumed 6% of capital costs with a minimum of $100 million be allocated for remedial design.
Project Management	EPA stated that "due to the high overall costs for major work activities, the professional/technical percentages were modified to lower than the recommended range presented in the guidance, to better reflect realistic costs for professional/technical services costs for these items." EPA used the following: • 2% of technology capital costs for project management • 2% for institutional controls and site-wide monitoring costs • 5% of capital costs for MNR monitoring, long-term O&M, institutional control periodic, and 5-year site review periodic costs	Not used. These costs are covered in other indirect categories listed below (e.g. agency and responsible party oversight).
Responsible Party Oversight and Project Management	Not used.	The LWG developed costs assuming that during construction, personnel and equipment will be required to monitor the construction activities for quality assurance. Staffing is assumed to include an office project manager and support and eight field representatives. Costs are normalized over a monthly construction basis at $539,000 per month
Agency Oversite and Project Management	Not used.	The LWG based costs on historical agency oversight costs experienced by the LWG, normalized over a monthly construction basis schedule with adjustments for multiple projects occurring during construction. Costs are increased by 1.11 times to account for inflation and are estimated to be $324,000 per month.
Engineering Support During Construction	Not used.	The LWG based engineering construction support costs to cover personnel providing engineering support as issues arise and to support the construction management. Staffing is assumed to cover an office project engineer and support and two resident engineers for the multiple remedial sites. Costs are normalized over a monthly construction basis schedule and are estimated to be $117,000 per month.
Contractor Project Management	Not used.	The contractor will have a number of staff to manage the project including a project manager, superintendents, foremen, quality control and health and safety officers, and a project engineer. The estimated costs for this crew and direct costs is $1 million per season.
Construction Management	EPA stated that "due to the high overall costs for major work activities, the professional/technical percentages were modified to lower than the recommended range presented in the guidance, to better reflect realistic costs for professional/technical services costs for these items." EPA used the following percentages for Construction Management: • 3% of technology capital costs for remedial design • 3% of technology capital costs for institutional controls development • 6% of capital costs for MNR monitoring	Not used. Covered in other indirect categories.

Cost Item	EPA Approach	LWG Approach
Special Insurance and Bonding	EPA did not include this cost item.	The costs associated with special insurance and bonding are assumed to be 5% of total capital costs based on professional experience.
Pre-Construction Capital Costs		
Institutional Controls Prior to Construction	**Description:** EPA assumed labor and material costs to develop and maintain Institutional Control costs each year until construction is completed. **Unit Cost:** Lump sum costs for labor and materials to initially develop information devices for Fish Consumption Advisory and RNA and then maintain each year. $3.7 million initially (with 15% contingency, 2% project management, 2% remedial design, and 3% construction management). EPA evenly distributed this cost over the 7 years of construction. **Quantity:** NA	**Description and Unit Cost:** Used DEQ's (2016) recommended Institutional Control costs except included 40% for contingency. and had all costs occurring in year 0 because this work would need to be completed up front. **Quantity:** NA
Monitored Natural Recovery	**Description:** EPA assumed an effort at time 0 to assess the current condition of MNR within the harbor. **Unit Cost:** EPA assumed costs based on the LWG 2012 FS, increased for inflation, at $3,686/acre (with 20% contingency, 5% project management, 8% remedial design, and 6% construction management). **Quantity:** EPA applied the unit cost 1,937 acres of Portland Harbor.	**Description and Unit Cost:** EPA's assumptions and costing approach appears reasonable except applying 8% for design (EPA 2000; Exhibit 5-8) and 40% for contingency. **Quantity:** Assumed 1,937 acres of Portland Harbor from EPA estimate.
Long-term Periodic Costs		
Site-Wide Monitoring and MNR Periodic Costs	**Description:** EPA assumed costs to monitor site-wide, MNR, EMNR, and cap areas. EPA included 20% contingency, 5% project management, and 10% for technical support. EPA, in a response to the LWG technical questions on the Feasibility Study/Proposed Plan, stated that this line item captures costs for various construction monitoring activities. The LWG feels that the costs presented here are not sufficient for construction monitoring. **Unit Cost:** EPA assumed three cost elements: • EPA assumed costs based on the LWG 2012 FS, increased for inflation, for MNR ($3,686/acre) • EPA assumed costs based on the LWG 2012 FS, increased for inflation, excluding the 50 surface sediment samples, for site-wide monitoring ($957,659) • EPA assumed costs based on the LWG 2012 FS, increased for inflation, for long-term cap monitoring and reactive cap monitoring ($21,828,717) **Quantity:** EPA assumed 1,937 acres of MNR, 148 acres of cap, and 114 acres of reactive cap. EPA assumed monitoring will occur in years 2, 4, 6, 8, 10, 14, 18, 22, 26, and 30.	**Description and Unit Cost:** Costing approach appears reasonable and consistent with the LWG approach for post construction monitoring, except the 50 surface sediment samples for site-wide monitoring were added back in and need to include 6% for design (EPA 2000; Exhibit 5-8) and 40% for contingency. **Quantity:** The LWG assumed monitoring will occur in years 2, 4, 6, 8, 10, 14, 18, 22, 26, and 30.
Long-term Operations and Maintenance and Institutional Controls Periodic Costs	**Description:** EPA assumed 5% of all caps need to be replaced. Also includes an additional mobilization/demobilization for this week. EPA included 20% contingency, 5% project management, and 10% for technical support. **Unit Costs:** For institutional controls, EPA developed costs that were 10% of the estimated costs for initial institutional control development and then applied 10% contingency, 5% project management, and 10% technical support. **Quantity:** EPA assumed these O&M and institutional control costs occur every 5 years for 30 years.	The LWG separated cap O&M from institutional controls.
Long-term Operations and Maintenance Periodic Costs	EPA combined Long-term Operations and Maintenance and Institutional Controls Periodic Costs.	**Description:** The LWG also assumed 5% of the caps would need to be replaced. The raw cap construction costs were increased to include 10% for mobilization/demobilization, 6% for design (EPA 2000; Exhibit 5-8), and 40% for contingency. **Unit Cost:** 5% of the total cap purchase and installation costs. **Quantity:** The LWG assumed these O&M costs occur only in years 5 and 10 instead of every 5 years because historically caps show areas susceptible to erosion within the first few years of operation.
Long-term Institutional Controls Periodic Costs	EPA combined Long-term Operations and Maintenance and Institutional Controls Periodic Costs.	**Description and Unit Cost:** Used DEQ's (2016) recommended Institutional Control costs except included 40% for contingency. **Quantity:** The LWG assumed these long-term institutional control costs occur every year after the first 5 years of construction for 30 years.
5-Year Site Review Periodic Costs	**Description:** EPA assumed costs for labor and material for a site visit and 5-year site review period report. **Unit Cost:** EPA assumed a cost of $243,687 with 10% contingency, 5% project management, and 10% technical support. **Quantity:** EPA assumed these reviews occur every 5 years for 30 years.	**Description and Unit Cost:** EPA's costing approach appears reasonable, except the need to include 40% for contingency. **Quantity:** The LWG assumed these reviews occur every 5 years for 30 years.
Discount factor	EPA used a value of 7% for the discount rate.	The LWG used 2.3% as taken from the OMB Circular A-94 per EPA guidance because a number of parties are government-regulated utilities, or quasi-government agencies, which have different "cost of capital" than the private sector.
Miscellaneous		
Duration	EPA assumed the project duration was the sum of dredge duration, cap duration, and organoclay mat placement duration. EPA assumed 5,100 cy/day dredging, 3,900 cy/day capping, 4 acres/day mat placement, and 122 construction days per season. EPA also added a season before construction and one at the end of construction to represent mobilization/demobilization activities.	The LWG assumed that capping could occur concurrently with dredging across the site (capping in one SDU could occur while dredging in anther SDU was occurring). Therefore, duration was assumed to equal to the dredge duration. The LWG assumed 1,600 cy/day dredging, 2,600 cy/day capping, and 104 construction days per season. The LWG also added a season before construction and one at the end of construction to represent mobilization/demobilization activities.

Notes:
CWA - Clean Water Act
cy - cubic yard
DE - diatomaceous earth
DEQ – Oregon Department of Environmental Quality
DSL - Oregon Department of State Lands

EMNR - enhanced monitoring
EPA - U.S. Environmental Protection Agency
FS - Feasibility Study
HUC - Hydrologic Unit Code
lf - linear foot
LWG - Lower Willamette Group
MNR - monitored natural recovery
NA - not applicable
NAPL - nonaqueous phase liquid
NRC - National Research Council
O&M - operations and maintenance
OMB - Office of Management and Budget
NAVD88 - North American Vertical Datum of 1988
POTW - Publicly Owned Treatment Works
PRG - preliminary remediation goal
PTW - principal threat waste
PP - Proposed Plan
RAL - remedial action level
RI - Remedial Investigation
RNA - regulated navigation area
SDU - sediment decision unit
sf - square foot
TSCA - Toxic Substances Control Act

Reference:

DEQ. 2016. *Email From Kevin Parrett of Oregon DEQ to Kristine Koch and Sean Sheldrake.* February 20,2016.
EPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 5540-R-00-002 OSWER 9355.0-75. July 2000.

Table 2. Comparison of EPA and LWG Cost Approach.

Alternative I DMM Scenario 2

Capital Costs			
Item	**EPA**	**LWG**	**Difference**
Direct Costs			
Mobilization/Demobilization	$9,045,000	$42,784,000	$33,700,000
Debris Removal and Disposal	$3,827,000	$3,779,000	$0
Obstruction Removal and Relocation	$15,146,000	$14,955,000	-$200,000
Erosion/Residual Control Measures (Dredge Water Quality Controls)	$25,228,000	$136,546,000	$111,300,000
Dredging of Contaminated Sediments (Open Water)	$38,183,000	$28,889,000	-$9,300,000
Dredging of Contaminated Sediments (Confined)	$2,897,000	$63,343,000	$60,400,000
Excavation of Riverbanks	$533,000	$3,337,000	$2,800,000
Dewatering and Water Treatment for Dredging Operations	$7,261,000	$31,465,000	$24,200,000
Subtitle C/TSCA Disposal	$68,536,000	$81,961,000	$13,400,000
Subtitle D Disposal	$280,706,000	$302,648,000	$21,900,000
Mitigation	$36,408,000	$62,900,000	$26,500,000
DSL Costs	-	$8,616,000	$8,616,000
Sand Placement for Technology Assignments	$20,353,000	$38,678,000	$18,300,000
Beach Mix Placement for Technology Assignments	$3,635,000	$11,425,000	$7,800,000
Armor Placement for Technology Assignments	$5,803,000	$16,473,000	$10,700,000
Reactive/GAC Placement for Technology Assignments	$44,759,000	$94,945,000	$50,200,000
Geofabric for Riverbanks	$303,000	$304,000	$0
Organoclay Mat Placement for Technology Assignments	$1,173,000	$1,159,000	$0
Transload Facility Development	$10,529,000	$37,660,000	$27,100,000
Subtotal	**$574,325,000**	**$981,867,000**	**$407,500,000**
Contingency	$114,865,000	$392,747,000	$277,900,000
Direct Cost Subtotal	**$689,190,000**	**$1,374,614,000**	**$685,400,000**
Indirect Costs			
Remedial Design	$13,784,000	$100,000,000	$86,200,000
Project Management	$13,784,000	-	$36,399,000
Responsible Party Oversight and Project Management	-	$29,432,000	
Agency Oversite and Project Management	-	$16,848,000	
Engineering Support During Construction	-	$9,204,000	
Contractor Project Management	-	$15,375,000	
Construction Management	$20,676,000	-	
Special Insurance and Bonding	-	$68,731,000	$68,731,000
Indirect Cost Subtotal	**$48,244,000**	**$239,590,000**	**$191,300,000**
TOTAL CAPITAL COST	**$737,434,000**	**$1,614,204,000**	**$876,800,000**
NPV Cost (see Table 3)	**$811,299,000**	**$1,772,629,000**	**$961,300,000**

Estimated Removal Volume (cy)	1,752,000	2,080,000	328,000
Estimated Total Cap Volume (cy)	814,000	1,230,000	416,000
Estimated Duration (Seasons)	7	15	8

Other Capital Costs			
Item	**EPA**	**LWG**	**Notes**
Establish Institutional Controls	$3,726,000	$11,020,000	EPA over construction duration; LWG Year 0
Initial MNR Monitoring	$10,197,000	$10,795,000	EPA/LWG Year 0

Periodic Costs			
Item	**EPA**	**LWG**	**Notes**
Long-term Monitoring and MNR	$38,426,000	$45,137,000	EPA/LWG Years 2, 4, 6, 8, 10, 14, 18, 22, 26, 30
Long-term O&M (Caps) and Institutional Controls	$5,972,000	-	EPA every 5 years
Long-term O&M (Caps)	-	$13,303,000	LWG years 5 and 10 only
Long-term Institutional Controls	-	$650,000	LWG every year after 5 years of construction
Long-term Institutional Controls	-	$50,000	LWG every 5 years
5-year Site Review	$308,000	$341,000	EPA/LWG every 5 years

Notes:

cy - cubic yard
DMM - dredge material management
DSL - Oregon Department of State Lands
EPA - U.S. Environmental Protection Agency
GAC - granular activated carbon
LWG - Lower Willamette Group
MNR - monitored natural recovery
NPV - net present value
O&M - Operations and Maintenance
TSCA - Toxic Substances Control Act

Table 3. Present Value Analysis Comparison.
Alternative I DMM Scenario 2

	EPA Approach											LWG Approach										
Year	Capital Costs (Institutional Controls)	Capital Costs (MNR)	Capital Costs (Technology Assignments)	Periodic Costs (Annual Caps O&M)	Periodic Costs (Institutional Controls)	Periodic Costs (Long-term Caps O&M and Institutional Controls)	Periodic Costs (Long-term Monitoring and MNR)	Periodic Costs (5-year Site Reviews)	Total Annual Expenditure	Discount Factor 7%	Present Value	Capital Costs (Institutional Controls)	Capital Costs (MNR)	Capital Costs (Technology Assignments)	Periodic Costs (Annual Caps O&M)	Periodic Costs (Institutional Controls)	Periodic Costs (Long-term Caps O&M and Institutional Controls)	Periodic Costs (Long-term Monitoring and MNR)	Periodic Costs (5-year Site Reviews)	Total Annual Expenditure	Discount Factor 2.3%	Present Value
0	$532,286	$10,197,000	$105,347,714	-	-	$0	$0	$0	$116,077,000	1.0000	$116,077,000	$11,020,000	$10,795,000	$107,613,600	$0	$0	-	$0	$0	$129,428,600	1.0000	$129,428,600
1	$532,286	$0	$105,347,714	-	-	$0	$0	$0	$105,880,000	0.9346	$98,953,271	$0	$0	$107,613,600	$0	$0	-	$0	$0	$107,613,600	0.9775	$105,194,135
2	$532,286	$0	$105,347,714	-	-	$0	$38,426,000	$0	$144,306,000	0.8734	$126,042,449	$0	$0	$107,613,600	$0	$0	-	$45,137,000	$0	$152,750,600	0.9555	$145,959,262
3	$532,286	$0	$105,347,714	-	-	$0	$0	$0	$105,880,000	0.8163	$86,429,619	$0	$0	$107,613,600	$0	$0	-	$0	$0	$107,613,600	0.9341	$100,517,171
4	$532,286	$0	$105,347,714	-	-	$0	$38,426,000	$0	$144,306,000	0.7629	$110,090,357	$0	$0	$107,613,600	$0	$0	-	$45,137,000	$0	$152,750,600	0.9131	$139,469,868
5	$532,286	$0	$105,347,714	-	-	$5,972,000	$0	$308,000	$112,160,000	0.7130	$79,968,530	$0	$0	$107,613,600	$13,303,000	$700,000	-	$0	$341,000	$121,957,600	0.8925	$108,850,568
6	$532,286	$0	$105,347,714	-	-	$0	$38,426,000	$0	$144,306,000	0.6663	$96,157,181	$0	$0	$107,613,600	$0	$650,000	-	$45,137,000	$0	$153,400,600	0.8725	$133,836,095
7	$0	$0	$0	-	-	$0	$0	$0	$0	0.6227	$0	$0	$0	$107,613,600	$0	$650,000	-	$0	$0	$108,263,600	0.8528	$92,332,167
8	$0	$0	$0	-	-	$0	$38,426,000	$0	$38,426,000	0.5820	$22,364,282	$0	$0	$107,613,600	$0	$650,000	-	$45,137,000	$0	$153,400,600	0.8337	$127,885,701
9	$0	$0	$0	-	-	$0	$0	$0	$0	0.5439	$0	$0	$0	$107,613,600	$0	$650,000	-	$0	$0	$108,263,600	0.8149	$88,227,051
10	$0	$0	$0	-	-	$5,972,000	$38,426,000	$308,000	$44,706,000	0.5083	$22,726,263	$0	$0	$107,613,600	$13,303,000	$700,000	-	$45,137,000	$341,000	$167,094,600	0.7966	$133,108,588
11	$0	$0	$0	-	-	$0	$0	$0	$0	0.4751	$0	$0	$0	$107,613,600	$0	$650,000	-	$0	$0	$108,263,600	0.7787	$84,304,449
12	$0	$0	$0	-	-	$0	$0	$0	$0	0.4440	$0	$0	$0	$107,613,600	$0	$650,000	-	$0	$0	$108,263,600	0.7612	$82,409,041
13	$0	$0	$0	-	-	$0	$0	$0	$0	0.4150	$0	$0	$0	$107,613,600	$0	$650,000	-	$0	$0	$108,263,600	0.7441	$80,556,247
14	$0	$0	$0	-	-	$0	$38,426,000	$0	$38,426,000	0.3878	$14,902,265	$0	$0	$107,613,600	$0	$650,000	-	$45,137,000	$0	$153,400,600	0.7273	$111,575,332
15	$0	$0	$0	-	-	$5,972,000	$0	$308,000	$6,280,000	0.3624	$2,276,161	$0	$0	$0	$0	$700,000	-	$0	$341,000	$1,041,000	0.7110	$740,144
16	$0	$0	$0	-	-	$0	$0	$0	$0	0.3387	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.6950	$451,755
17	$0	$0	$0	-	-	$0	$0	$0	$0	0.3166	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.6794	$441,598
18	$0	$0	$0	-	-	$0	$38,426,000	$0	$38,426,000	0.2959	$11,368,867	$0	$0	$0	$0	$650,000	-	$45,137,000	$0	$45,787,000	0.6641	$30,407,505
19	$0	$0	$0	-	-	$0	$0	$0	$0	0.2765	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.6492	$421,965
20	$0	$0	$0	-	-	$5,972,000	$0	$308,000	$6,280,000	0.2584	$1,622,871	$0	$0	$0	$0	$700,000	-	$0	$341,000	$1,041,000	0.6346	$660,599
21	$0	$0	$0	-	-	$0	$0	$0	$0	0.2415	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.6203	$403,204
22	$0	$0	$0	-	-	$0	$38,426,000	$0	$38,426,000	0.2257	$8,673,254	$0	$0	$0	$0	$650,000	-	$45,137,000	$0	$45,787,000	0.6064	$27,763,758
23	$0	$0	$0	-	-	$0	$0	$0	$0	0.2109	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.5927	$385,278
24	$0	$0	$0	-	-	$0	$0	$0	$0	0.1971	$0	$0	$0	$0	$0	$650,000	--	$0	$0	$650,000	0.5794	$376,615
25	$0	$0	$0	-	-	$5,972,000	$0	$308,000	$6,280,000	0.1842	$1,157,085	$0	$0	$0	$0	$700,000	-	$0	$341,000	$1,041,000	0.5664	$589,603
26	$0	$0	$0	-	-	$0	$38,426,000	$0	$38,426,000	0.1722	$6,616,784	$0	$0	$0	$0	$650,000	-	$45,137,000	$0	$45,787,000	0.5536	$25,349,869
27	$0	$0	$0	-	-	$0	$0	$0	$0	0.1609	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.5412	$351,780
28	$0	$0	$0	-	-	$0	$0	$0	$0	0.1504	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.5290	$343,871
29	$0	$0	$0	-	-	$0	$0	$0	$0	0.1406	$0	$0	$0	$0	$0	$650,000	-	$0	$0	$650,000	0.5171	$336,140
30	$0	$0	$0	-	-	$5,972,000	$38,426,000	$308,000	$44,706,000	0.1314	$5,872,898	$0	$0	$0	$0	$700,000	-	$38,426,000	$341,000	$39,467,000	0.5055	$19,951,020
TOTAL	**$3,726,000**	**$10,197,000**	**$737,434,000**	**-**	**-**	**$35,832,000**	**$384,260,000**	**$1,848,000**	**$1,173,297,000**		**$811,299,000**	**$11,020,000**	**$10,795,000**	**$1,614,204,000**	**$26,606,000**	**$17,200,000**	**-**	**$444,659,000**	**$2,046,000**	**$2,126,530,000**		**$1,772,629,000**

Notes:
MNR - monitored natural recovery
O&M - operations and maintenance